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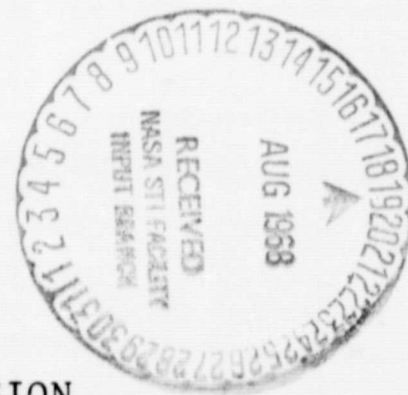
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JOHN F. KENNEDY
SPACE CENTER

TR-661
June 17, 1968

SATURN V UNIFIED S-BAND TRANSMITTING SYSTEM
ELECTROMAGNETIC COMPATIBILITY
TEST REPORT



TELEMETRIC SYSTEMS DIVISION

N 69-15824

(ACCESSION NUMBER)

(THRU)

32

1

(PAGES)

(CODE)

TMX-61362

07

(NASA CR OR TMX OR AD NUMBER)

(CATEGORY)

FACILITY FORM 602

JOHN F. KENNEDY SPACE CENTER, NASA

TR-661

SATURN V UNIFIED S-BAND TRANSMITTING SYSTEM

ELECTROMAGNETIC COMPATIBILITY

TEST REPORT

by

L. D. Adams

ITT-FEDERAL ELECTRIC CORPORATION

CONTRACT NO. NAS10-4967

for
EMC SECTION, RF SYSTEMS BRANCH, TELEMETRIC SYSTEMS DIVISION
DIRECTOR INFORMATION SYSTEMS

June 17, 1968

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DEFINITION OF TERMS

- ANTENNA HAT - A cavity placed in front of the vehicle antenna to couple the radiated energy to the coaxial cable.
- CLAM SHELL - The movable service structure which encloses the vehicle in the service position.
- CLOSED LOOP - The vehicle antenna hat connected to the GSE via coaxial cable bypassing the parasitic antenna system.
- ECCOSORB - Trade name of a microwave absorbent material.
- OPEN LOOP - The vehicle antenna hat connected to the parasitic antenna via coaxial line.
- PARASITIC ANTENNA SYSTEM - VAB roof antennas, semi-flexible cables, and antenna hats that transfer radiation from the vehicle antennas (CCS and CSM) to the VAB roof antennas.

ABBREVIATIONS

| | |
|--------------------|--|
| CCS | Command and Communications Systems |
| CSM | Command Service Module |
| dB | Decibel |
| dBm | Decibels with reference to one milliwatt |
| dBm/MHz | Decibels with reference to one milliwatt per megahertz |
| dBW/m ² | Decibels with reference to one watt per square meter |
| EMC | Electromagnetic compatibility |
| GHz | Gigahertz |
| GSE | Ground Support Equipment |
| IF | Intermediate frequency |
| IU | Instrument Unit |
| kHz | Kilohertz |
| kHz/cm | Kilohertz per centimeter |
| LUT | Launch Umbilical Tower |
| MHz | Megahertz |
| MHz/cm | Megahertz per centimeter |
| MSO | Manned Spacecraft Operations |
| RF | Radio frequency |
| VAB | Vehicle Assembly Building |

SECTION I

INTRODUCTION

A. PURPOSE

This report presents the results derived from the unified S-band (USB) electromagnetic compatibility (EMC) tests which were conducted on the Command and Communications System (CCS) and Command Service Module (CSM) parasitic antenna systems and transponders of the AS-501 launch vehicle in the Vehicle assembly Building (VAB). The tests were performed to locate the cause of malfunction which existed when both CCS and CSM systems were operated simultaneously.

B. SCOPE

This report describes the tests conducted (1) on the roof of the VAB to determine the CCS and CSM parasitic antenna terminal power and the CCS parasitic antenna system RF leakage; and (2) around the Instrument Unit (IU) of the launch vehicle to determine the power density radiated from the CCS antenna hats, the isolation obtained from the Eccosorb covers, and the amount of isolation obtained from the adjustable platform B of the service structure.

C. VAB ROOF TEST LOCATION

The CCS and CSM parasitic antenna terminal power and the CCS parasitic antenna system RF leakage tests were conducted on the roof of the VAB. The location of the parasitic antenna systems with respect to the Apollo/Saturn launch vehicle, VAB, and USB is shown in figure 1. The electromagnetic compatibility (EMC) measurement position and the placements of the EMC receiving antenna with respect to the parasitic antenna systems on the VAB roof is shown in figure 2.

D. ADJUSTABLE PLATFORM B TEST LOCATION

The physical orientation of the clam shell and the adjustable platform B with respect to the IU is shown in figure 3. The IU measurement locations with respect to the CCS directional and omnidirectional antenna inside the adjustable platform B is shown in figure 4.

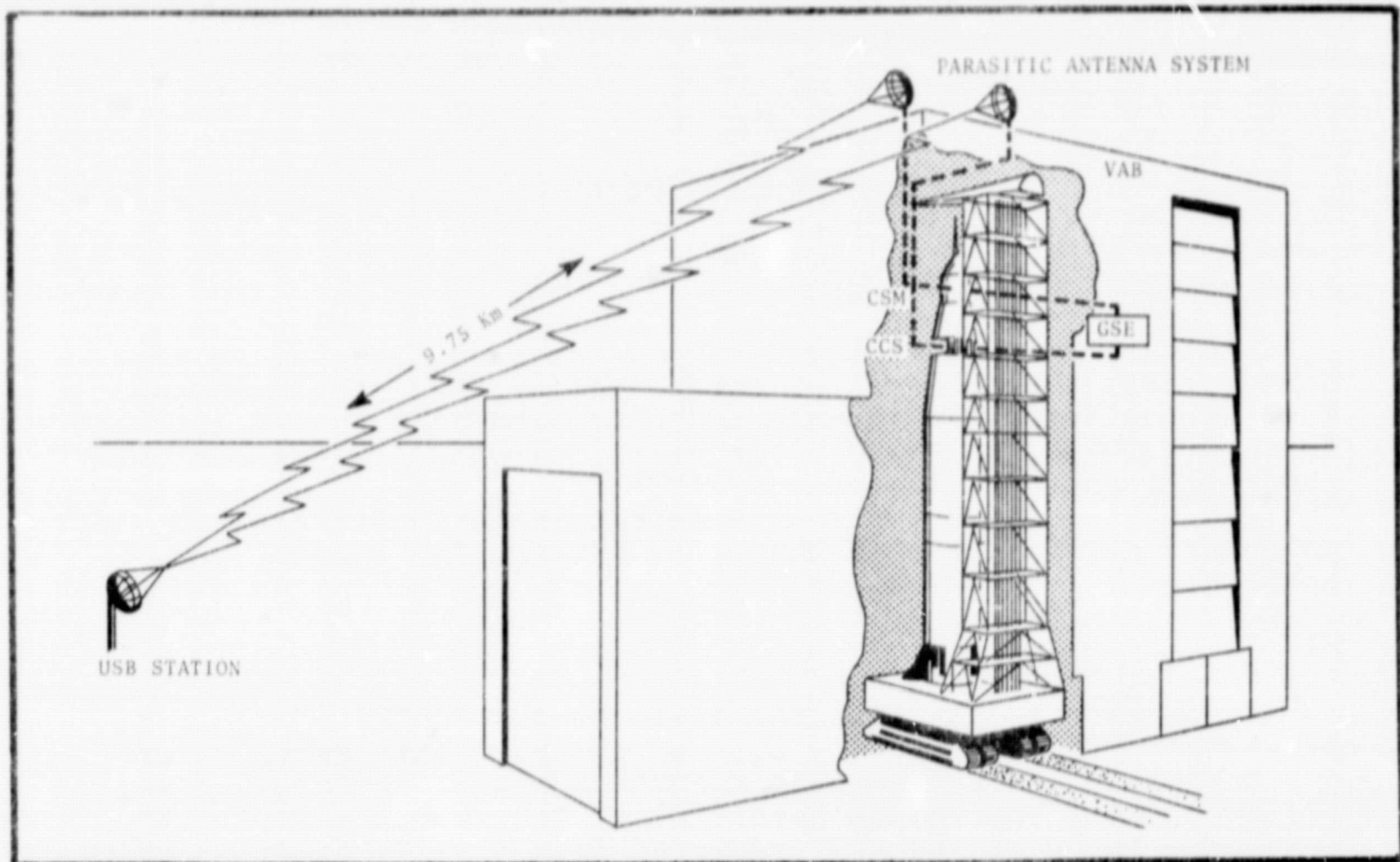


Figure 1. Location of Parasitic Antenna Systems with Respect to the Launch Vehicle, VAB Roof, and USB Site.

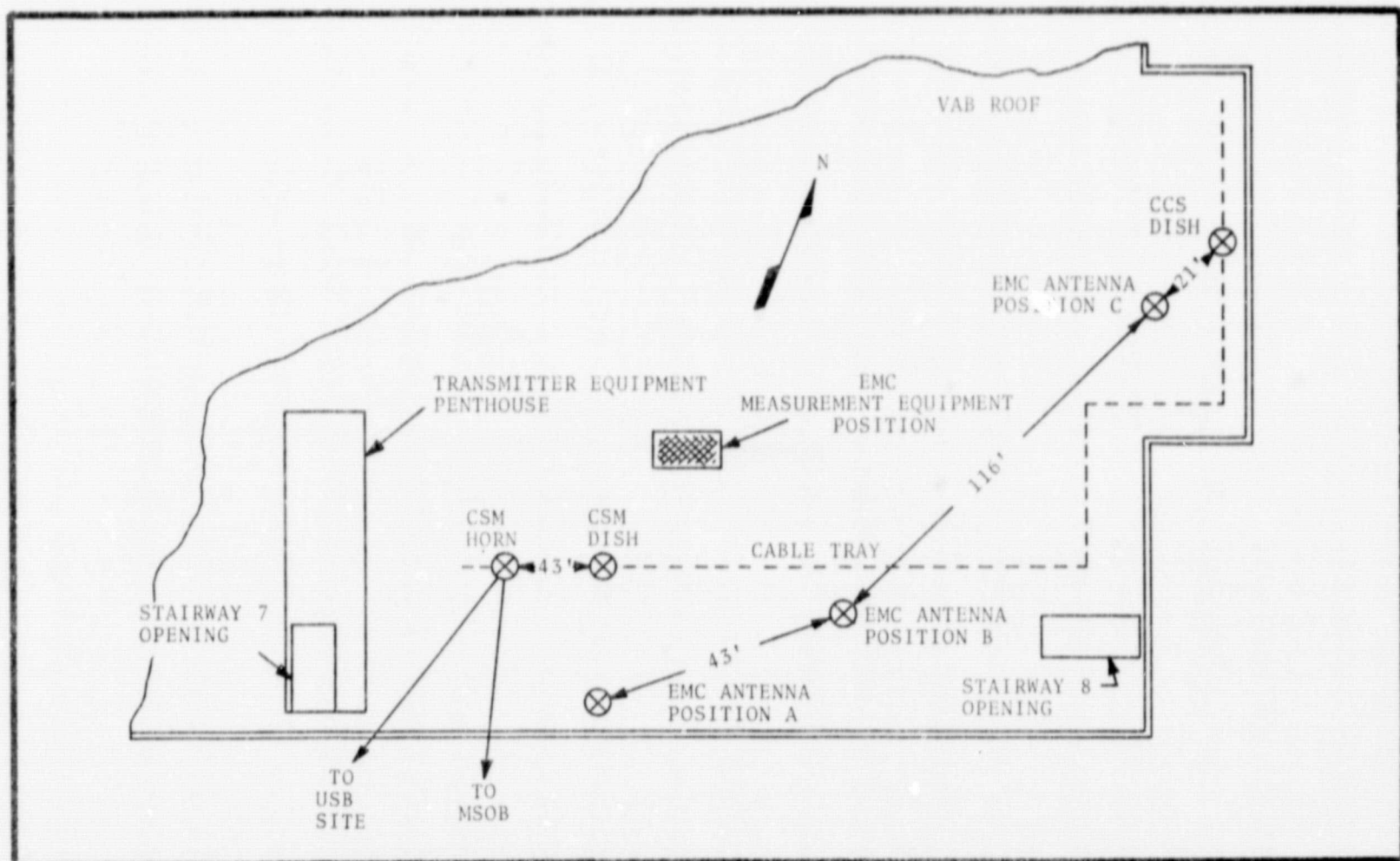


Figure 2. EMC Measurement Position on the Roof of the VAB.

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SECTION II

CCS AND CSM PARASITIC ANTENNA TERMINAL POWER MEASUREMENTS

A. GENERAL

The parasitic antenna terminal power measurements were taken to determine the actual power delivered to the CCS and CSM parasitic antennas from their respective transponders.

B. CCS PARASITIC ANTENNA TERMINAL POWER MEASUREMENTS

1. Test Equipment. The test equipment used to obtain the power measurements is listed in table 1.

Table 1. CCS Parasitic Antenna Terminal Power Measurement Test Equipment.

| Test Equipment | Manufacturer | Model | Serial No. |
|-----------------------------|------------------|----------------|-------------------------|
| Calibrated Signal Generator | Hewlett-Packard | 8616A | 411-00101 |
| Camera Mount | Hewlett-Packard | 196B | 422-01567 |
| Dual Directional Coupler | Hewlett-Packard | 777D | 02928 |
| Isolator | Cascade Research | CM-12-67 | 23046 |
| S-Band Antenna | Polarad | CA-S | 13-11 |
| Spectrum Analyzer | Hewlett-Packard | 8551A/ 851A | 502-00385/ 439-00098 |
| Tunable Preselection Filter | Empire | PF-190B | 126 |
| 2.0 GHz Band Reject Filter | Hewlett-Packard | 8439A | 25 |

2. Measurement Configuration. The measurement configuration is shown in figure 5. During normal operation, power from the vehicle CCS transponder is delivered to the CCS parasitic dish antenna on the roof of the VAB from an antenna hat placed over the vehicle antenna through a semi-flexible transmission line.

For these measurements a dual directional coupler was inserted in series with the transmission line near the parasitic antenna on the VAB roof. The EMC measurement system was connected to the forward port of the dual directional coupler; the reverse port was terminated in 50 ohms.

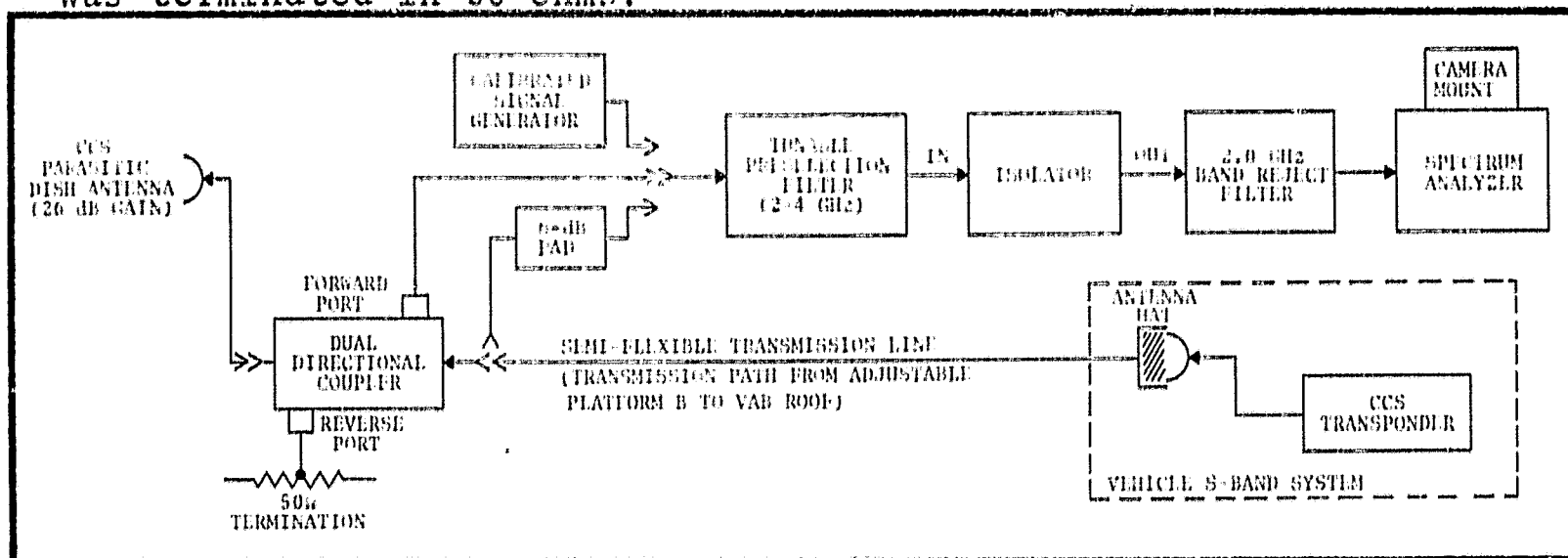


Figure 5. CCS Parasitic Antenna Terminal Power Measurement Configuration.

3. Calibration. The EMC measurement system was calibrated prior to and immediately following each measurement. With the measurement system disconnected from the dual directional coupler, the IF GAIN control on the display section of the spectrum analyzer was set to 80 dB and the ATTENUATOR control on the RF section was set to 0 dB. These settings place the spectrum analyzer in its most sensitive operating range. The calibrated signal generator was then connected to the tunable preselection filter using a calibrated RF cable. The calibrated signal generator output was adjusted to obtain full-scale deflection on the CRT of the spectrum analyzer at frequencies of 2282.5 MHz, 2285 MHz, and 2287.5 MHz. The tunable preselection filter was tuned to peak at each frequency. The calibrated full-scale sensitivity of the EMC measurement system is the calibrated signal generator power output level less the known loss in the calibrated RF cable. Calibration photographs taken at center frequencies of 2282.5, 2285, and 2287.5 MHz are shown in figures 6, 7, and 8 respectively. The calibration photographs show that the EMC measurement system had an essentially flat frequency response over the spectral region of interest.

4. Quality Assurance. The tunable preselection filter, isolator, and 2.0 GHz band reject filter were used in the EMC measurement system to prevent:

- a. signals generated by the spectrum analyzer from feeding into the antenna system under test

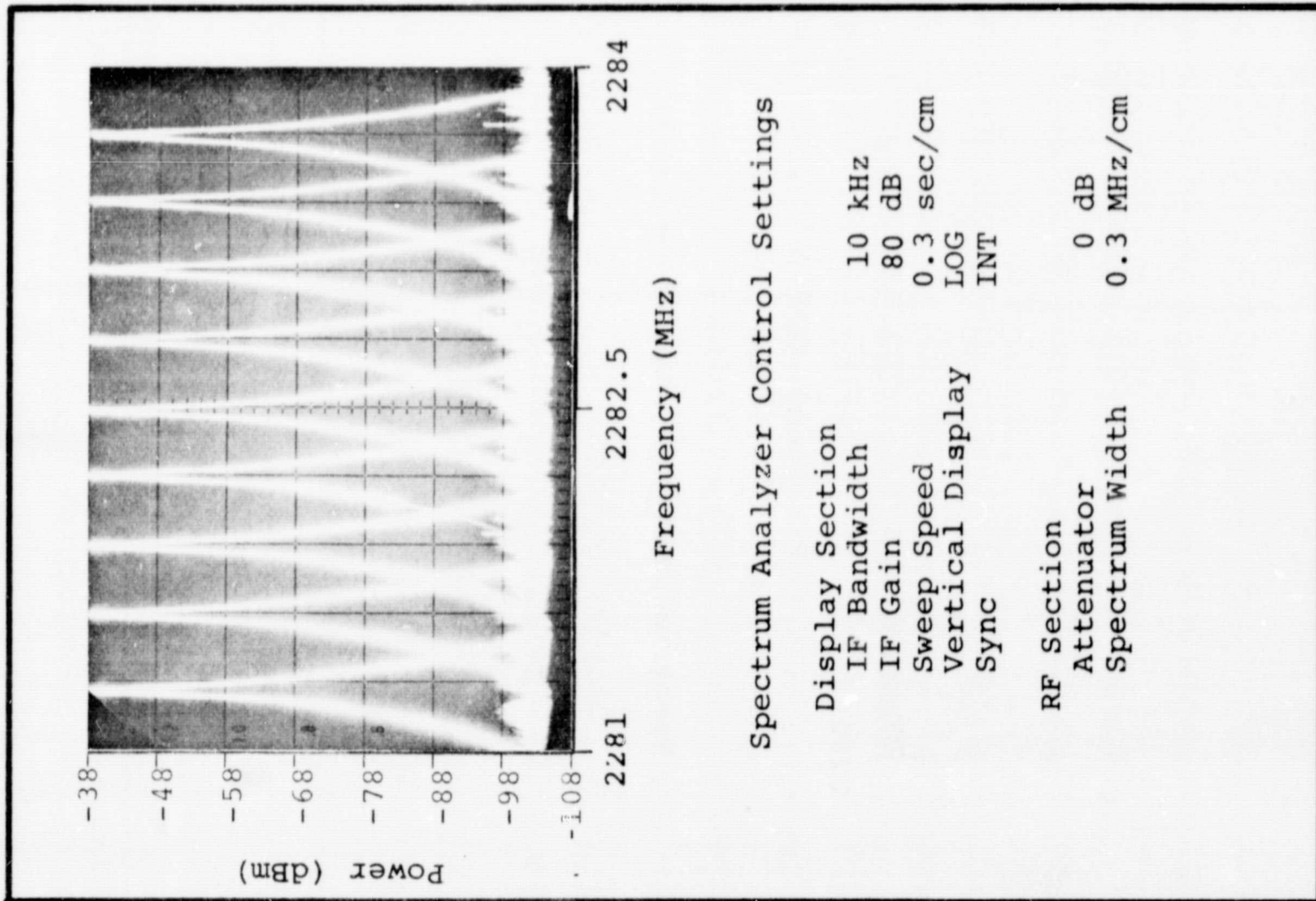


Figure 6. EMC Measurement System Calibration Photograph ($F_C = 2282.5$ MHz).

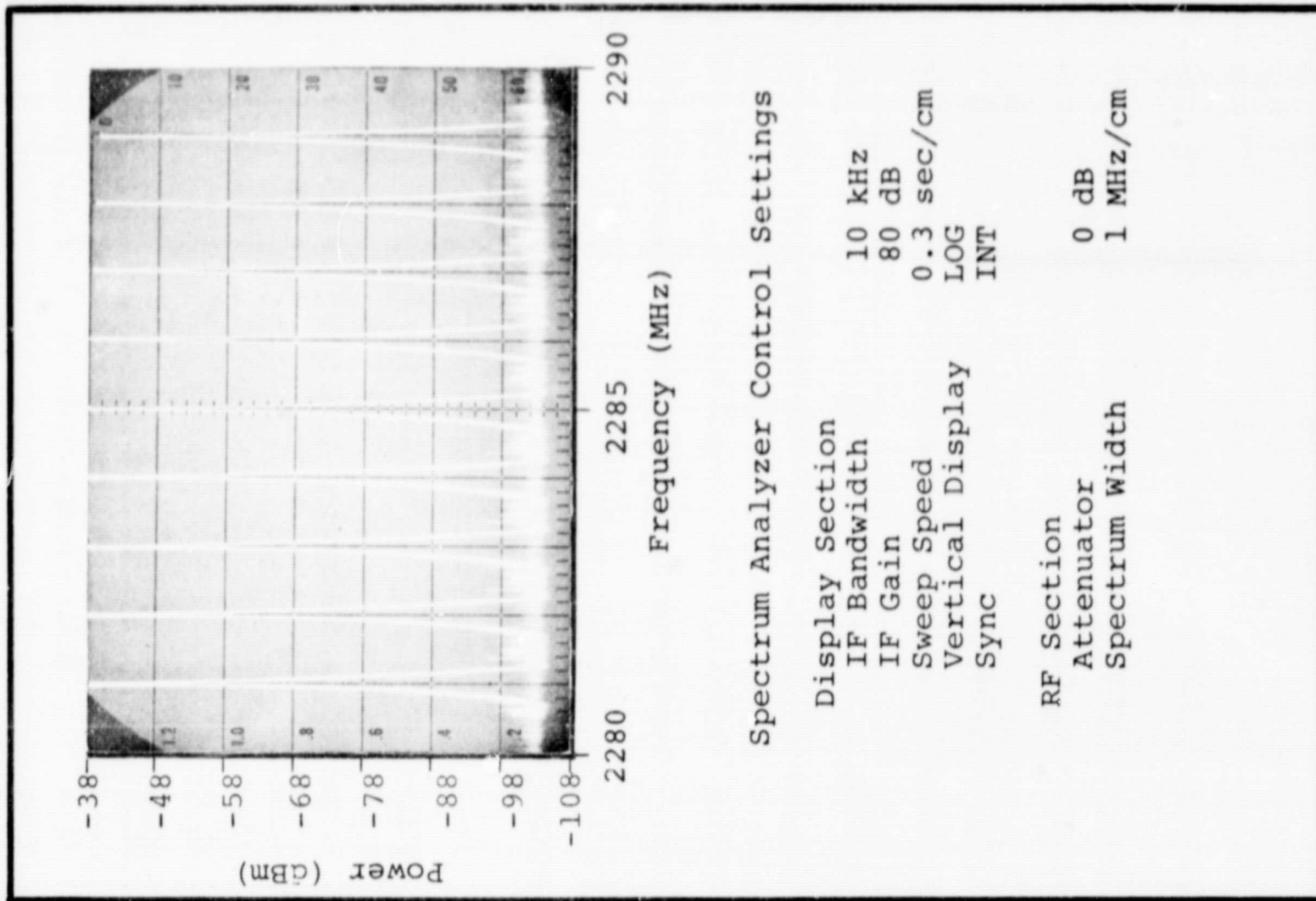


Figure 7. EMC Measurement System Calibration Photograph ($F_C = 2285$ MHz).

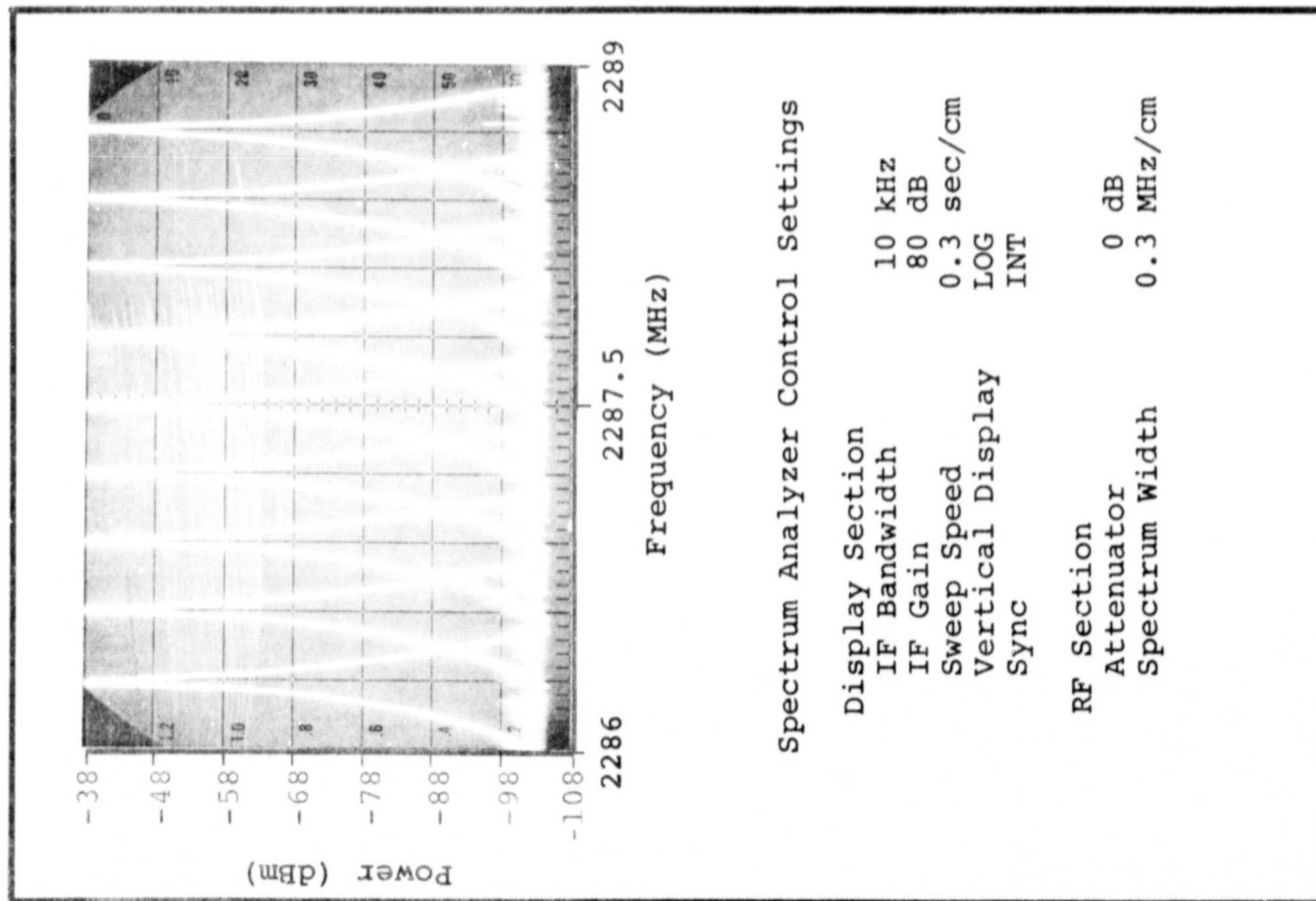


Figure 8. EMC Measurement System Calibration Photograph ($F_c = 2287.5$ MHz)

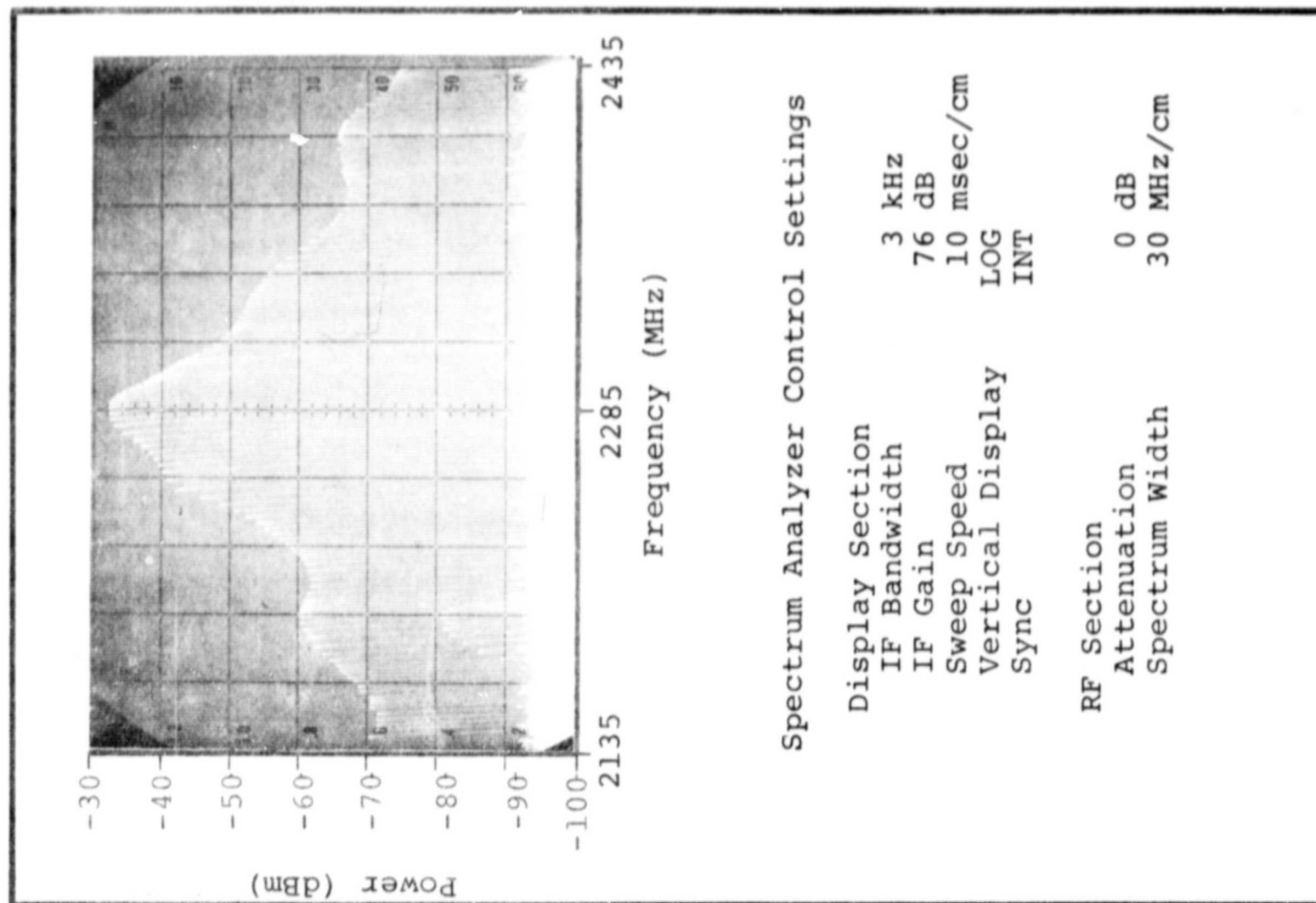


Figure 9. EMC Measurement System Roll-Off Characteristics.

b. extraneous signals from mixing with the spectrum analyzer local oscillator fundamental frequency and harmonics.

A photograph of the EMC measurement system roll-off characteristics is shown in figure 9.

5. Test Procedure. With the EMC measurement system connected to the forward port of the dual directional coupler (fig. 5), the spectrum analyzer was tuned to 2282.5 MHz, the center frequency of the CCS. The spectrum width on the display section of the spectrum analyzer was set to 0.3 MHz/cm to display both upper and lower sidebands on the CRT of the spectrum analyzer. It was observed that the 20 dB attenuation at the forward port of the dual directional coupler was too great to permit a full-scale deflection on the CRT of the spectrum analyzer even with the spectrum analyzer operating in its most sensitive range (fig. 10). The dual directional coupler was removed from the line and a 6-dB pad was inserted in its place. Full-scale deflection was then obtained (fig. 11). The spectrum width on the display section of the spectrum analyzer was reset to 1 MHz/cm to display a broader spectrum of the signal on the CRT of the spectrum analyzer (fig. 12).

6. Results. Figures 11 and 12 show that the transponder carrier power level at the CCS parasitic antenna terminal using a 6-dB pad in the transmission line measure -39 dBm. This power level correlates well with the power measured using a dual directional coupler in the transmission line (fig. 10).

The radiated power density may be calculated assuming free space conditions using the free space standard equation*

$$P_o = \frac{P_t G_t}{4\pi D^2} \quad (1)$$

where

P_o = power density at the receiving antenna

P_t = transmitting antenna terminal

G_t = transmitting antenna gain

D = transmission path distance

expressing the equation to read in dB

*This equation neglects physical effects such as multipath reflections, ground clutter, and ground plane reflections.

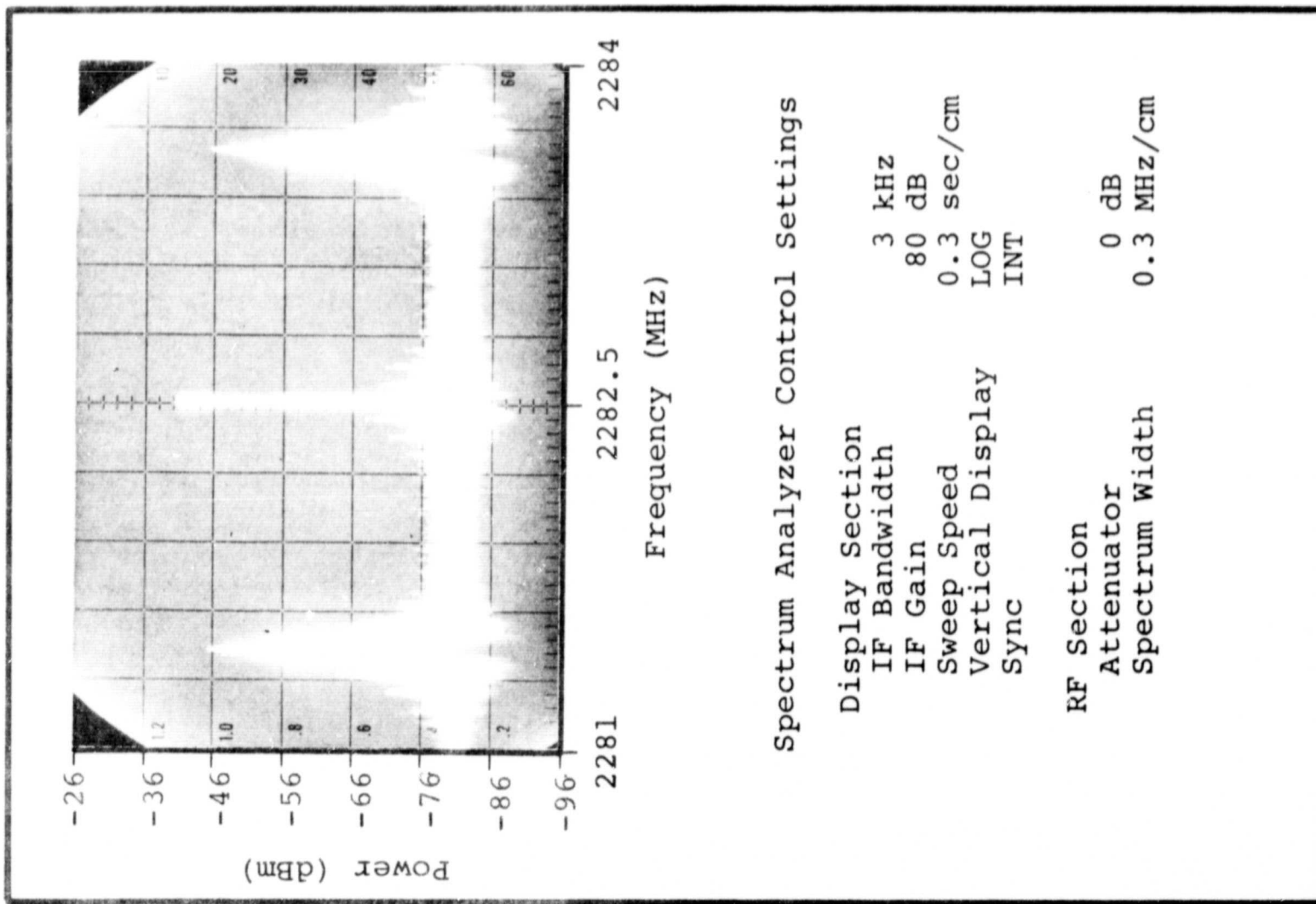


Figure 10. CCS Parasitic Antenna Terminal Power (Dual Directional Coupler in Line).

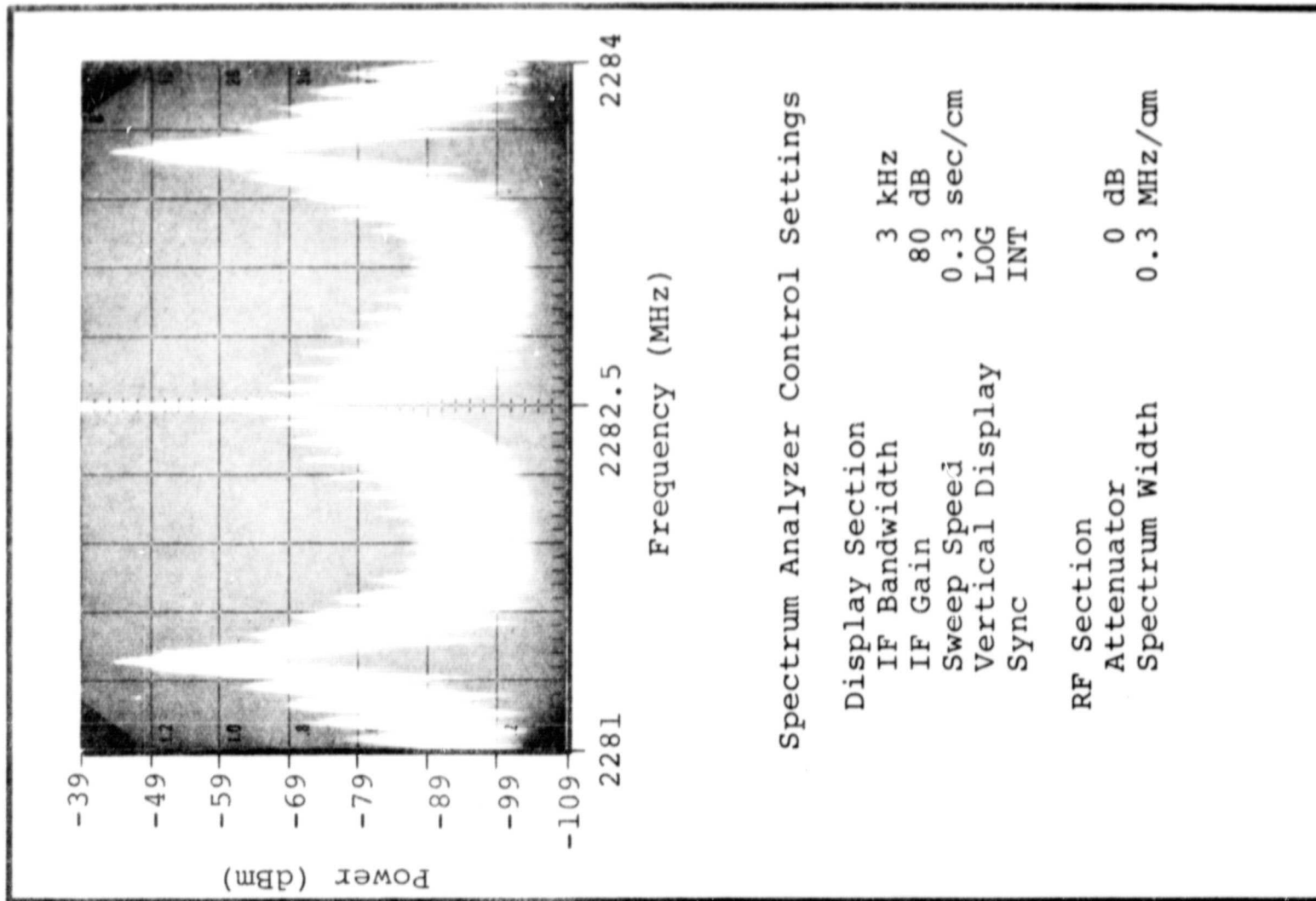


Figure 11. CCS Parasitic Antenna Terminal Power (6-dB Pad in Line).

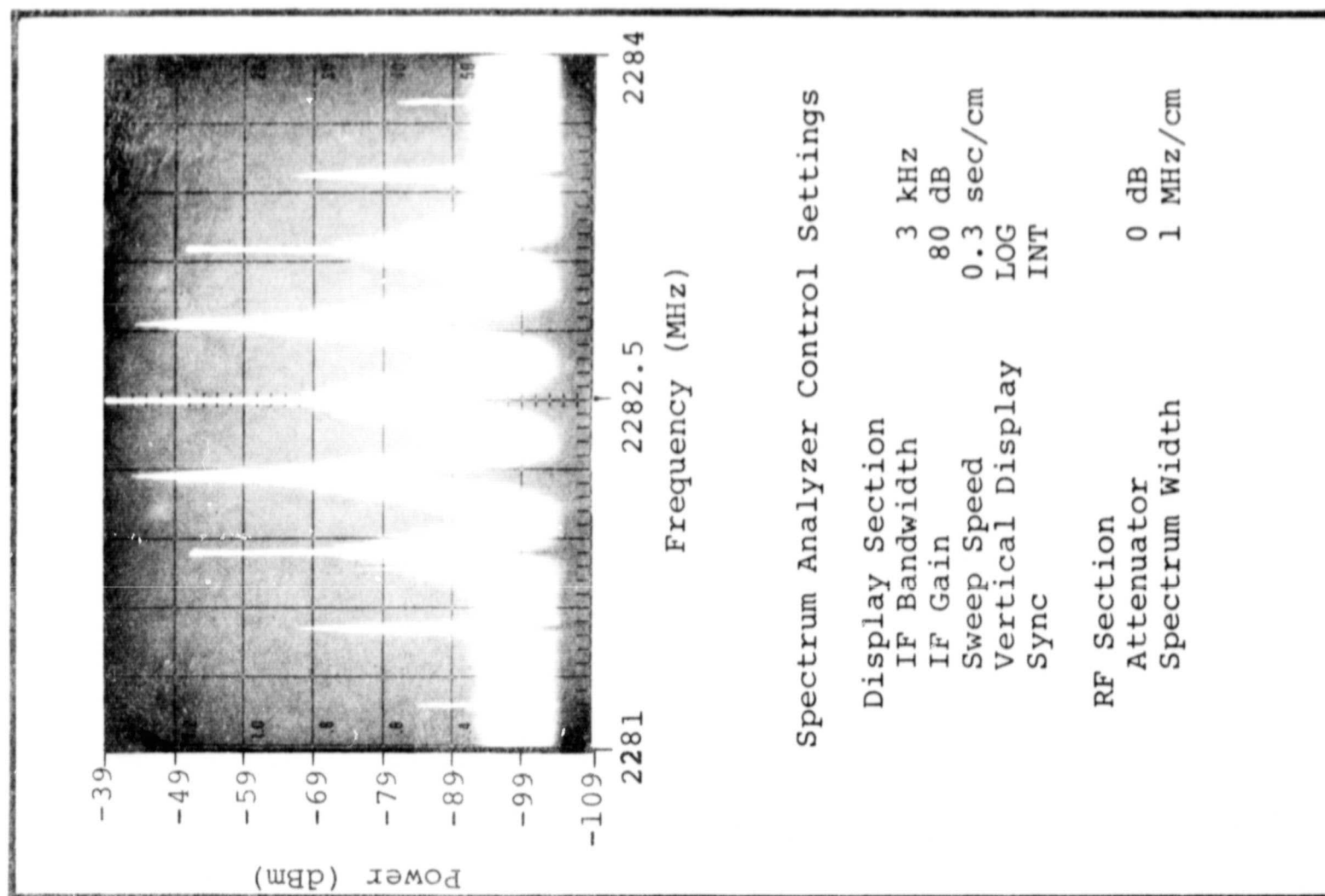


Figure 12. CCS Parasitic Antenna Terminal Power (6-dB Pad in Line).

$$P_o(\text{dB}) = 10 \log P_t + 10 \log G_t - [10 \log (4\pi) + 10 \log D^2] \quad (2)$$

The distance from the VAB to the receiving USB station is 9.75 km, the antenna gain 26 dB, and the transmitting antenna terminal power -39 dBm. Since the transmitting terminal power is already expressed in dBm and the antenna gain given in dB, equation (2) now becomes

$$\begin{aligned} P_o(\text{dBm/m}^2) &= -39 \text{ dBm} + 26 \text{ dB} - [10 \log (4\pi) + 10 \log D^2] \quad (3) \\ &= -39 \text{ dBm} + 26 \text{ dB} - [11 \text{ dB} + 77.7 \text{ dB meter}^2] \\ &= -39 \text{ dBm} + 26 \text{ dB} - 11 \text{ dB} - 77.7 \text{ dB meter}^2 \\ &= -101.7 \text{ dBm/m}^2 \end{aligned}$$

Expressing P_o in dBW/m², equation (2) becomes

$$\begin{aligned} P_o(\text{dBW/m}^2) &= -39 \text{ dBm} - 30 + 26 \text{ dB} - [10 \log (4\pi) + 10 \log D^2] \quad (4) \\ &= -131.7 \text{ dBW/m}^2 \end{aligned}$$

C. CSM PARASITIC ANTENNA TERMINAL POWER MEASUREMENTS

1. Test Equipment. The same test equipment used to perform the CCS parasitic antenna terminal power measurements was used to perform the CSM parasitic antenna terminal power measurements as listed in table 1.

2. Measurement Configuration. The measurement configuration shown in figure 13 is similar to the CCS measurement configuration. The CSM parasitic antenna system differs from the CCS parasitic system in that two antennas are used. A 30-dB-gain dish antenna is used for transmission to the Manned Spacecraft Operations (MSO) building and a 15-dB-gain horn antenna for transmission to the USB station. A 3-dB power divider is used to divide the power applied to the two antennas.

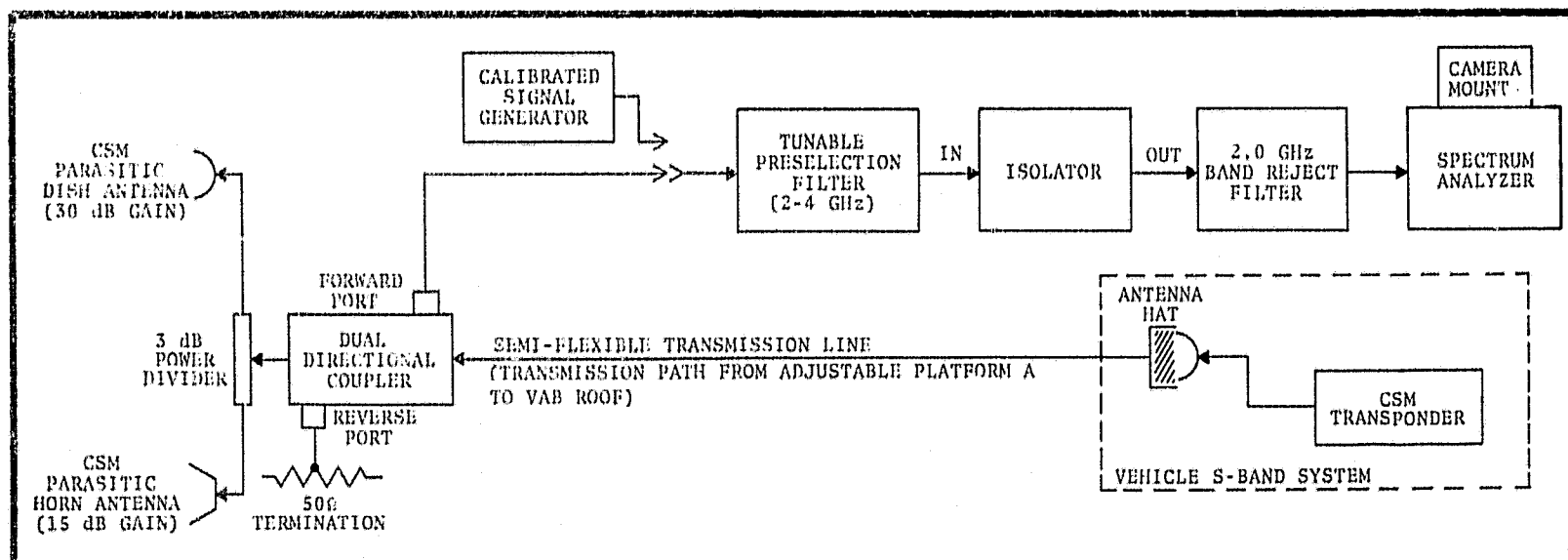


Figure 13. CSM Parasitic Antenna Terminal Power Measurement Configuration.

3. Calibration. The EMC measurement system calibration procedures are described in paragraph B.3.

4. Quality Assurance. Quality assurance for these measurements is described in paragraph B.4.

5. Procedure. With the EMC measurement system connected to the forward port of the dual directional coupler (fig. 13), the spectrum analyzer was tuned to 2287.5 MHz, the center frequency of the CSM. The spectrum width on the display section of the spectrum analyzer was set to 0.3 MHz/cm to display both upper and lower sidebands on the CRT of the spectrum analyzer. A photograph of the spectrum displayed is shown in figure 14. The spectrum width on the display section of the spectrum analyzer was reset to 1 MHz/cm to display a broader spectrum of the signal as shown in figure 15.

6. Test Results. Figures 14 and 15 show that the CSM transmitter carrier power level at the input to the 3-dB power divider measured +5 dBm. Thus, the actual power level available at each CSM antenna is +2 dBm. The radiated power density at the USB receiving antenna may be calculated assuming free space conditions using the free space standard equation as was done for the CCS system.

$$P_o = \frac{P_t G_t}{4\pi D^2} \quad (1)$$

and

$$P_o(\text{dB}) = 10 \log P_t + 10 \log G_t - [10 \log (4\pi) + 10 \log D^2] \quad (2)$$

The distance from the VAB to the receiving USB station is 9.75 km, the antenna gain 15 dB, and the transmitting antenna terminal power +2 dBm. Substituting these values in equation (2) we obtain

$$\begin{aligned} P_o(\text{dBm}/\text{m}^2) &= +2 \text{ dBm} + 15 \text{ dB} - 11 \text{ dB} - 77.7 \text{ dB meter}^2 \\ &= -71.7 \text{ dBm}/\text{m}^2 \end{aligned} \quad (5)$$

Expressing P_o in dBW/m², equation (5) becomes

$$\begin{aligned} P_o(\text{dBW}/\text{m}^2) &= +2 \text{ dBm} - 30 \text{ dB} + 15 \text{ dB} - 11 \text{ dB} - 77.7 \text{ dB meter}^2 \\ &= -101.7 \text{ dBW}/\text{m}^2 \end{aligned} \quad (6)$$

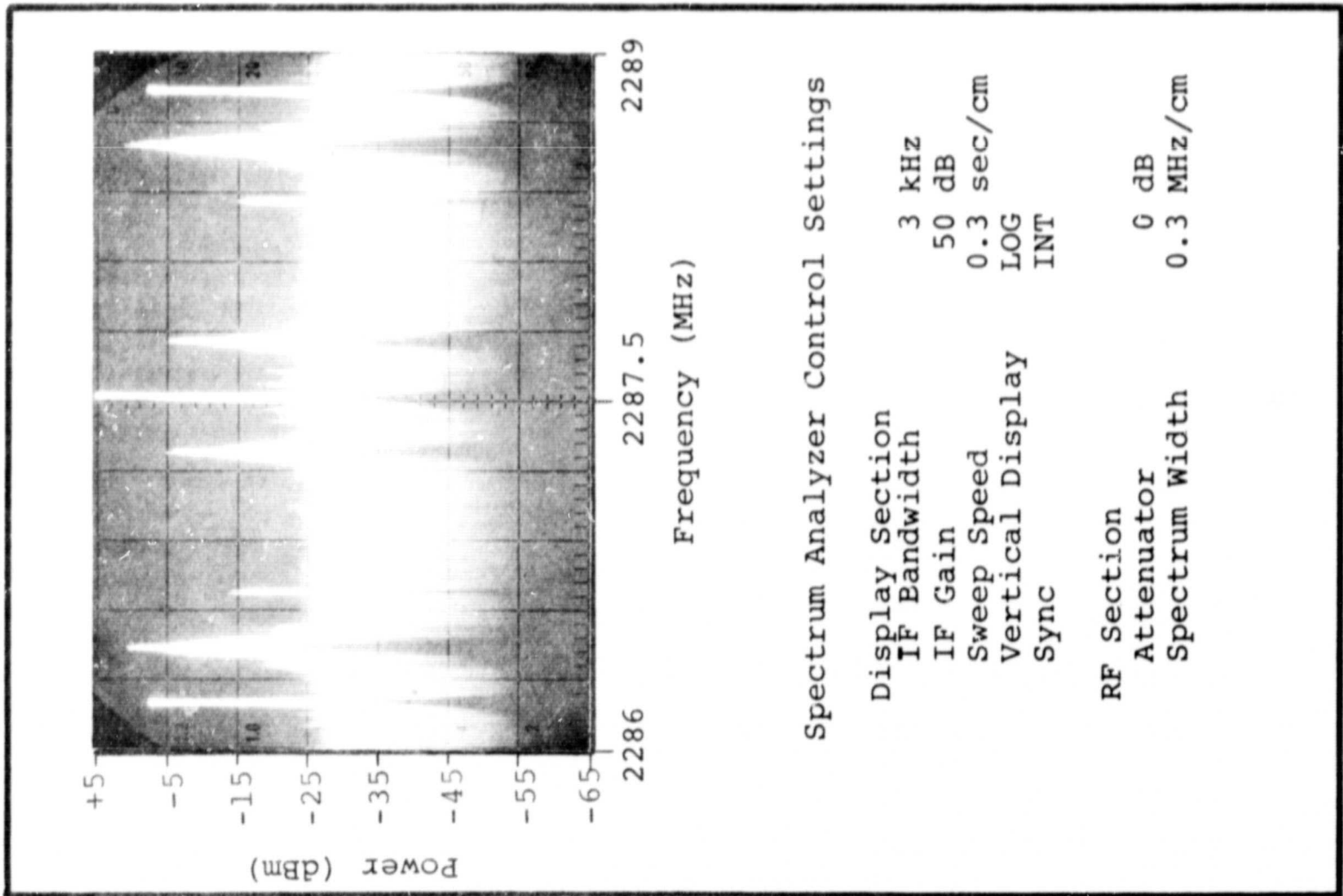


Figure 14. CSM Parasitic Antenna Terminal Power.

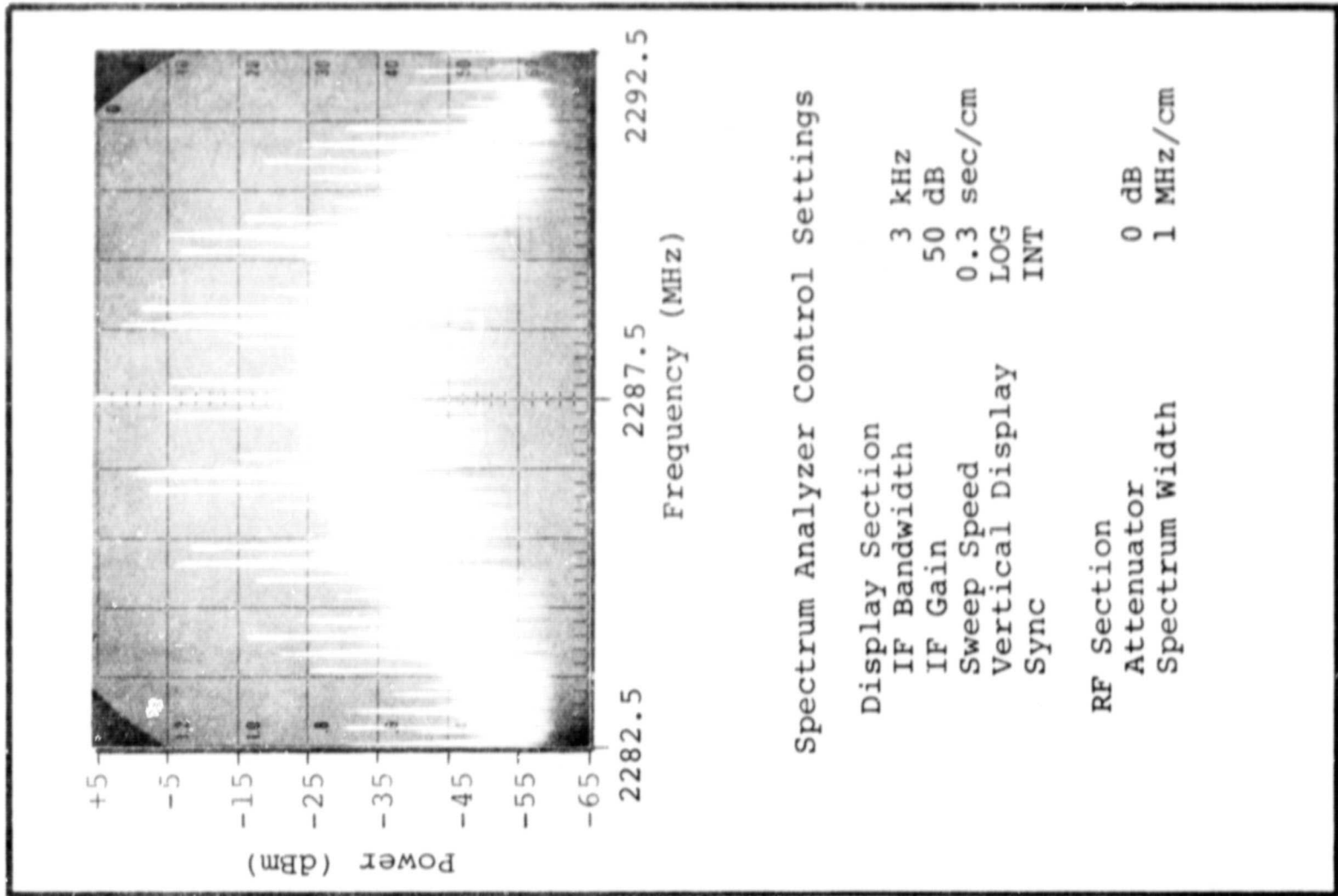


Figure 15. CSM Parasitic Antenna Terminal Power.

D. SPECTRUM OCCUPANCY

The CCS and CSM spectrum occupancy is shown in figures 16 and 17. The calculated power densities at the USB receiving antenna are plotted in figure 18. It can be seen from figure 18 that with both CCS and CSM systems operating simultaneously, the power density of the CSM lower sideband is within 3 dB of the power density of the center frequency of the CCS.

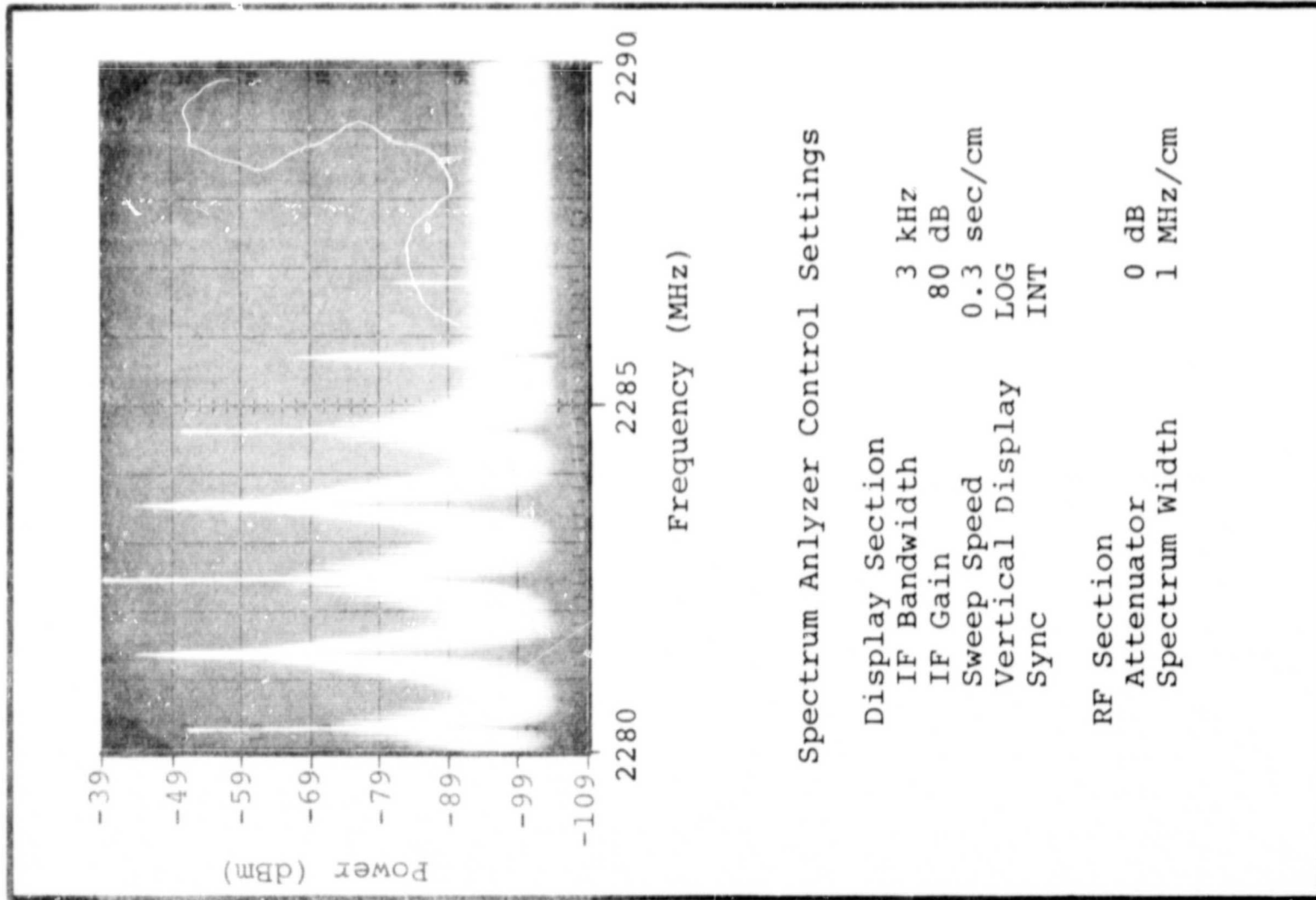


Figure 16. CCS Spectrum Occupancy.

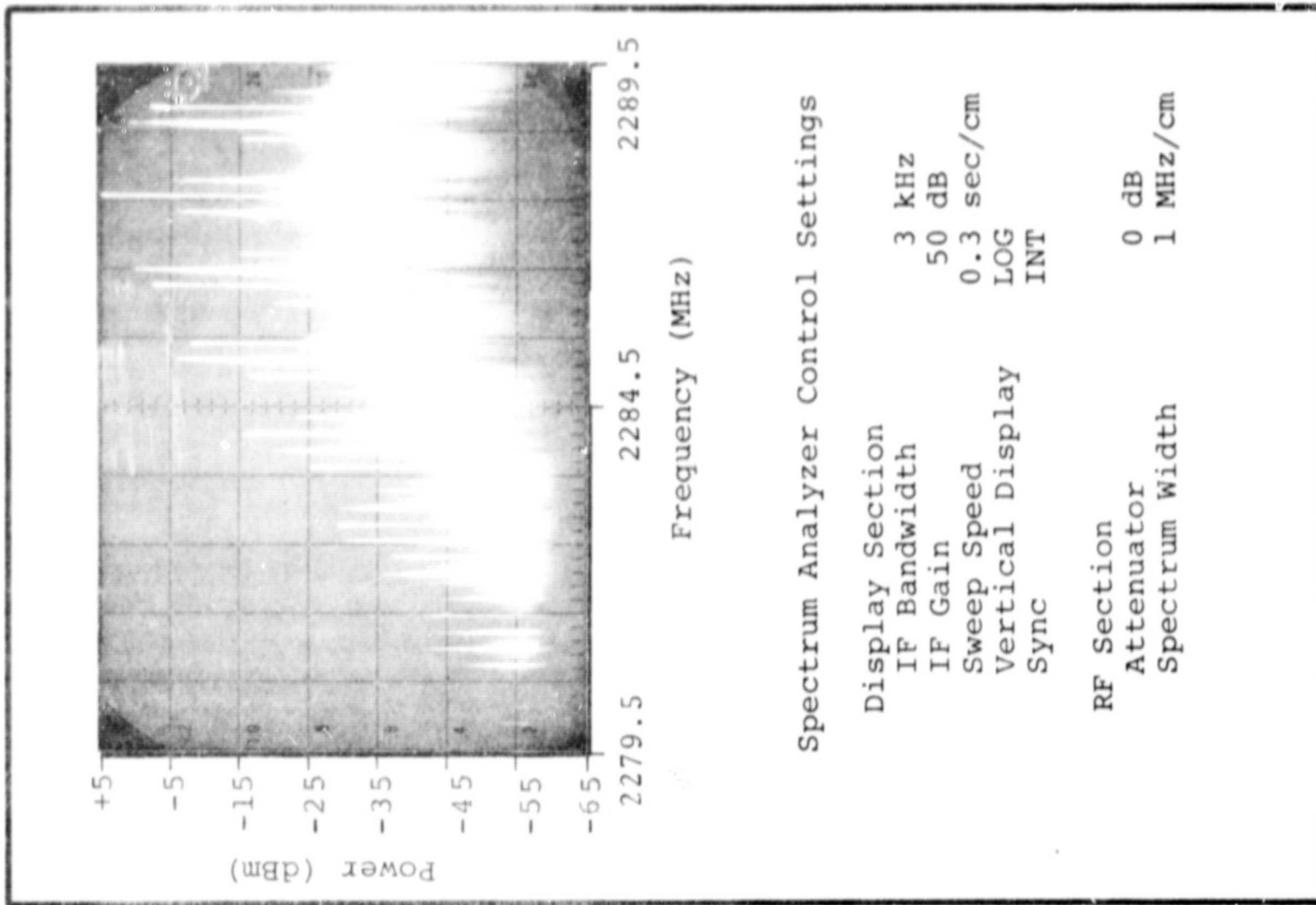


Figure 17. CSM Spectrum Occupancy

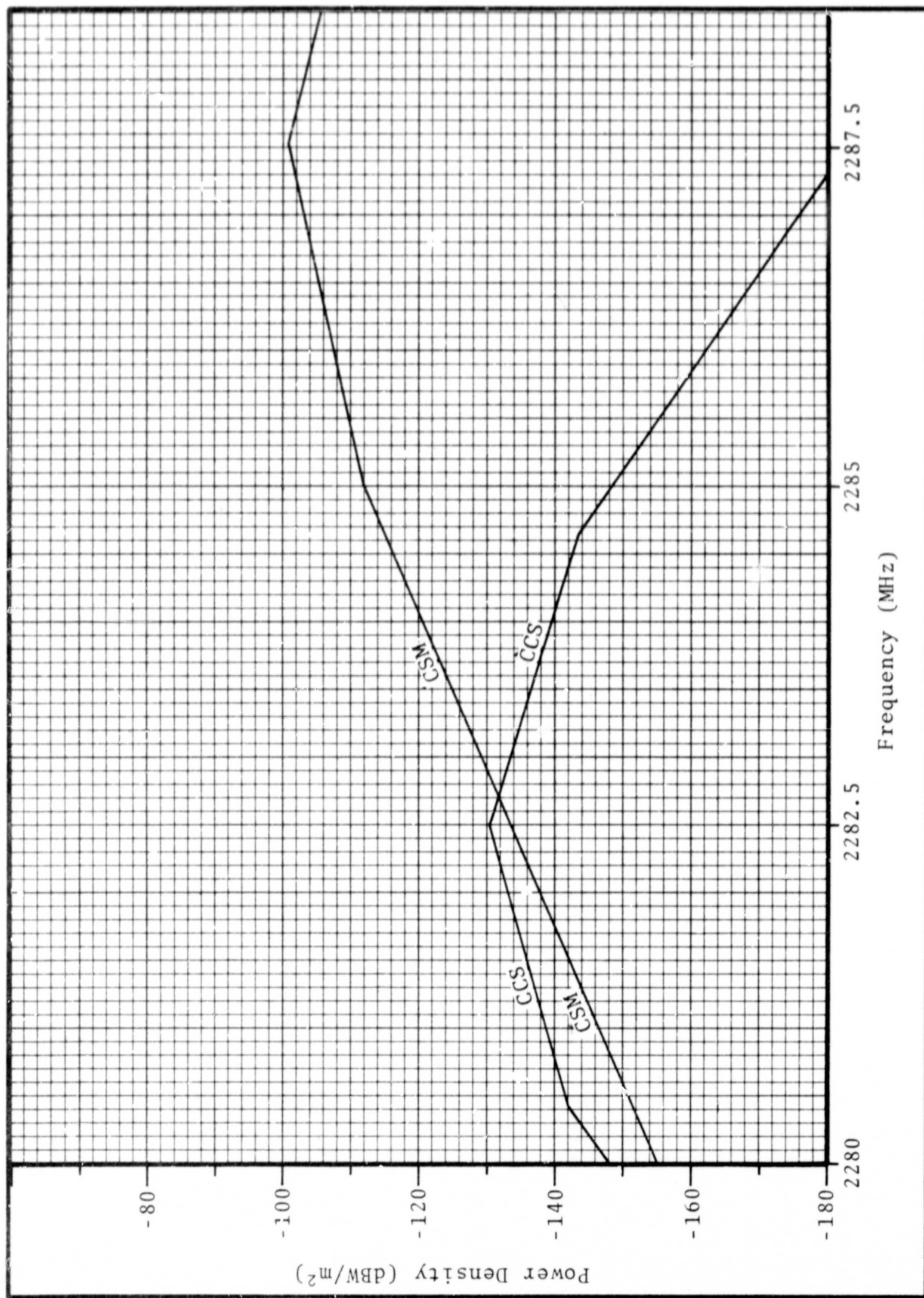


Figure 18. Calculated CCS and CSM Power Densities versus Frequency at the USB Site.

SECTION III

CCS PARASITIC ANTENNA LEAKAGE TEST

A. GENERAL

The CCS parasitic antenna leakage test was conducted on the roof of the VAB to determine the difference in RF emission characteristics with the CCS system operating in both the closed loop and open loop configurations. In the closed loop configuration, the CCS vehicle antenna hat is connected to the vehicle ground support equipment (GSE), located in the VAB, via coaxial cable. In open loop configuration, the CCS vehicle antenna hat is directly connected to the CCS parasitic antenna system through a semi-flexible transmission line. Measurements were taken at positions A, B, and C as shown in figure 2.

B. TEST PROCEDURE

1. Test Equipment. The test equipment used to perform the test is the same as that used to obtain the CCS parasitic antenna terminal power measurements and is listed in table 1.

2. Measurement Configuration. The measurement configuration is shown in figure 19. A coaxial switch mounted on the wall of the clam shell is used to transfer the CCS S-band transponder power to either the GSE or the CCS parasitic antenna system.

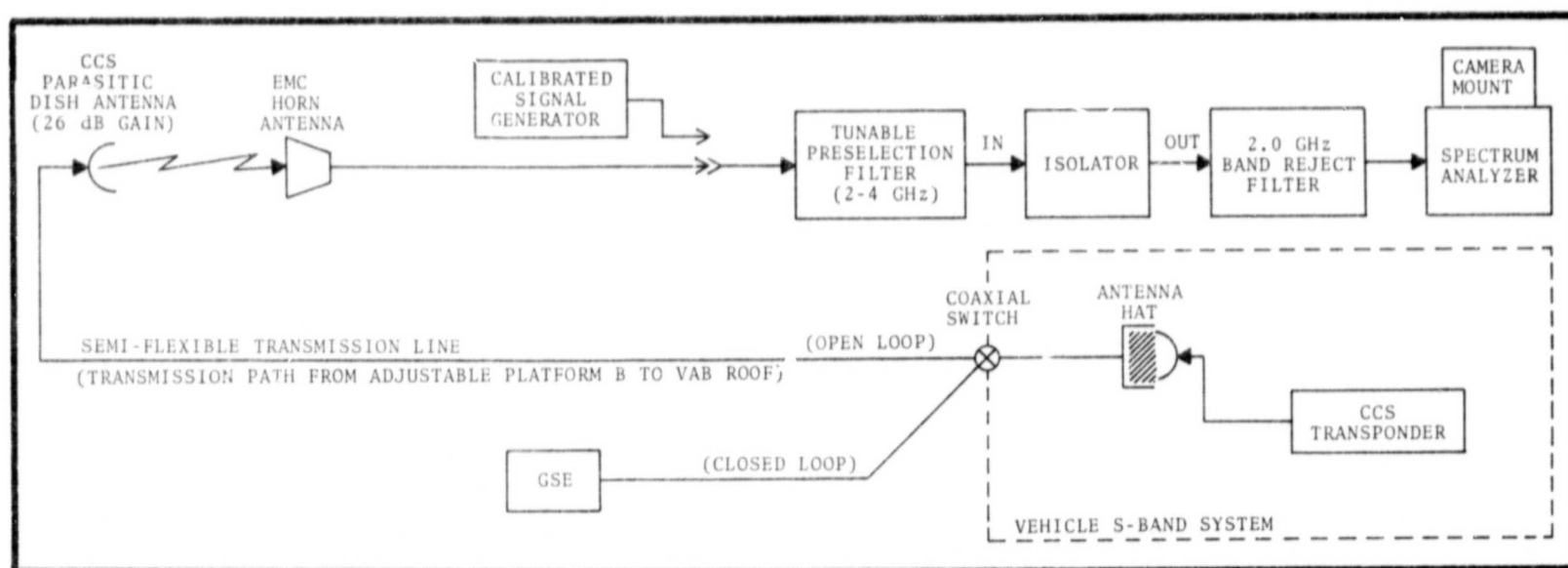


Figure 19. CCS Parasitic Antenna Leakage Measurement Configuration.

3. Calibration. The EMC measurement system calibration procedures are described in section II, paragraph B.3.

4. Quality Assurance. Quality assurance for these measurements are described in section II, paragraph B.4.

5. Procedure. The EMC measurement system was set up as shown in figure 19 and the spectrum analyzer was tuned to 2282.5 MHz, the center frequency of the CCS. The power radiating from the CCS vehicle high gain antenna enclosed in an antenna hat was measured with the EMC horn antenna positioned at points A, B, and C on the VAB roof (fig. 2) in both open loop and closed loop configurations. Eccosorb covers were then placed around the CCS vehicle high gain, low gain, and omnidirectional antenna hats. The power radiating from each of the CCS system antennas was again measured at points A, B, and C, but only in the closed loop configuration.

6. Results. The following are the results obtained from the CCS parasitic measurement tests:

a. the power measured at position A on the roof of the VAB was the same as in both open loop and closed loop configurations as shown in figures 20 and 21. The USB station, located 9.75 kilometers south of the VAB, verified that the power levels measured at the station were -82 dBm for both configurations.

b. with Eccosorb covers placed around the CCS vehicle antenna hats, no power was detected when operating in the closed loop configuration.

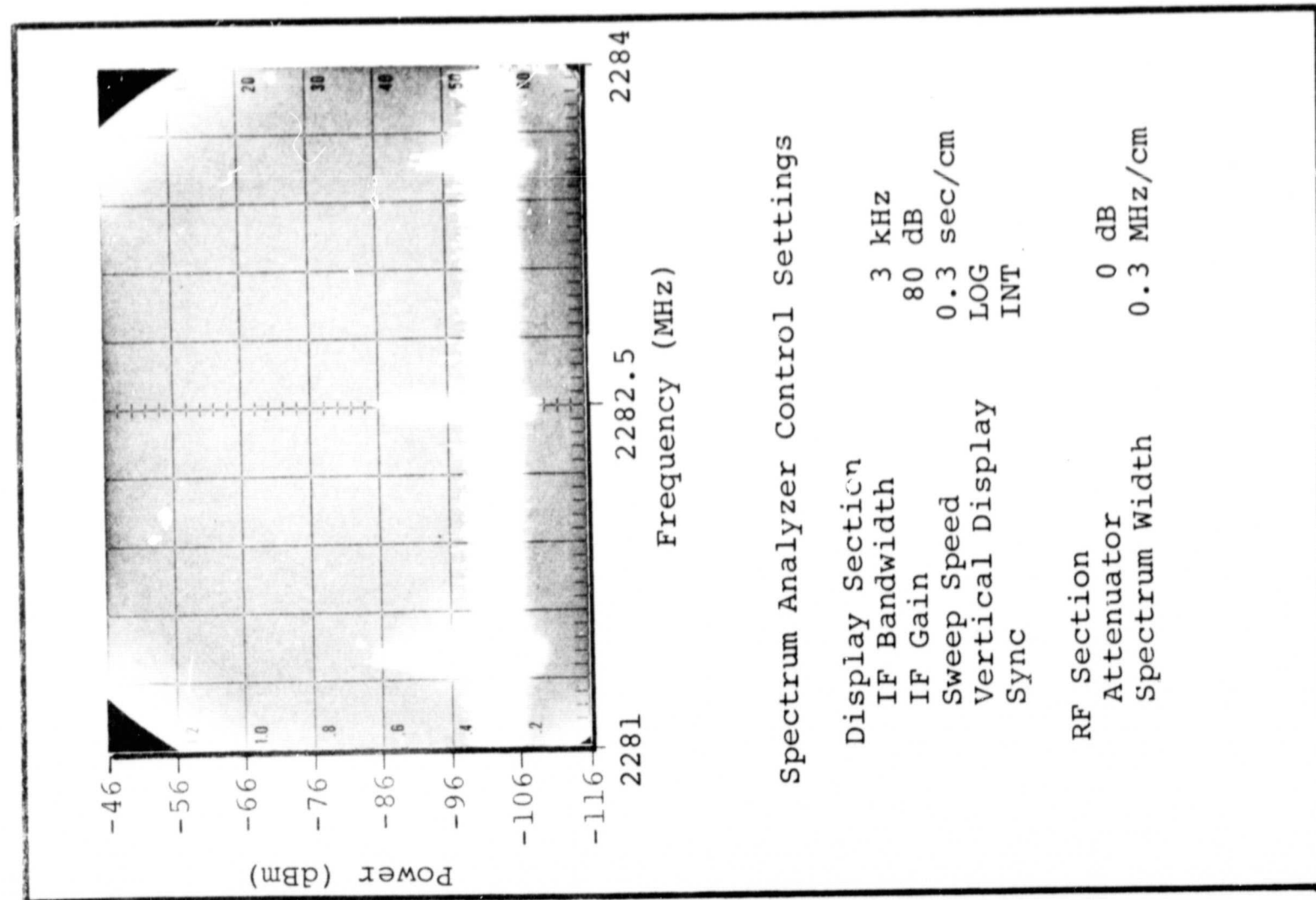


Figure 20. Typical CCS Vehicle High Gain Antenna Power (Open Loop).

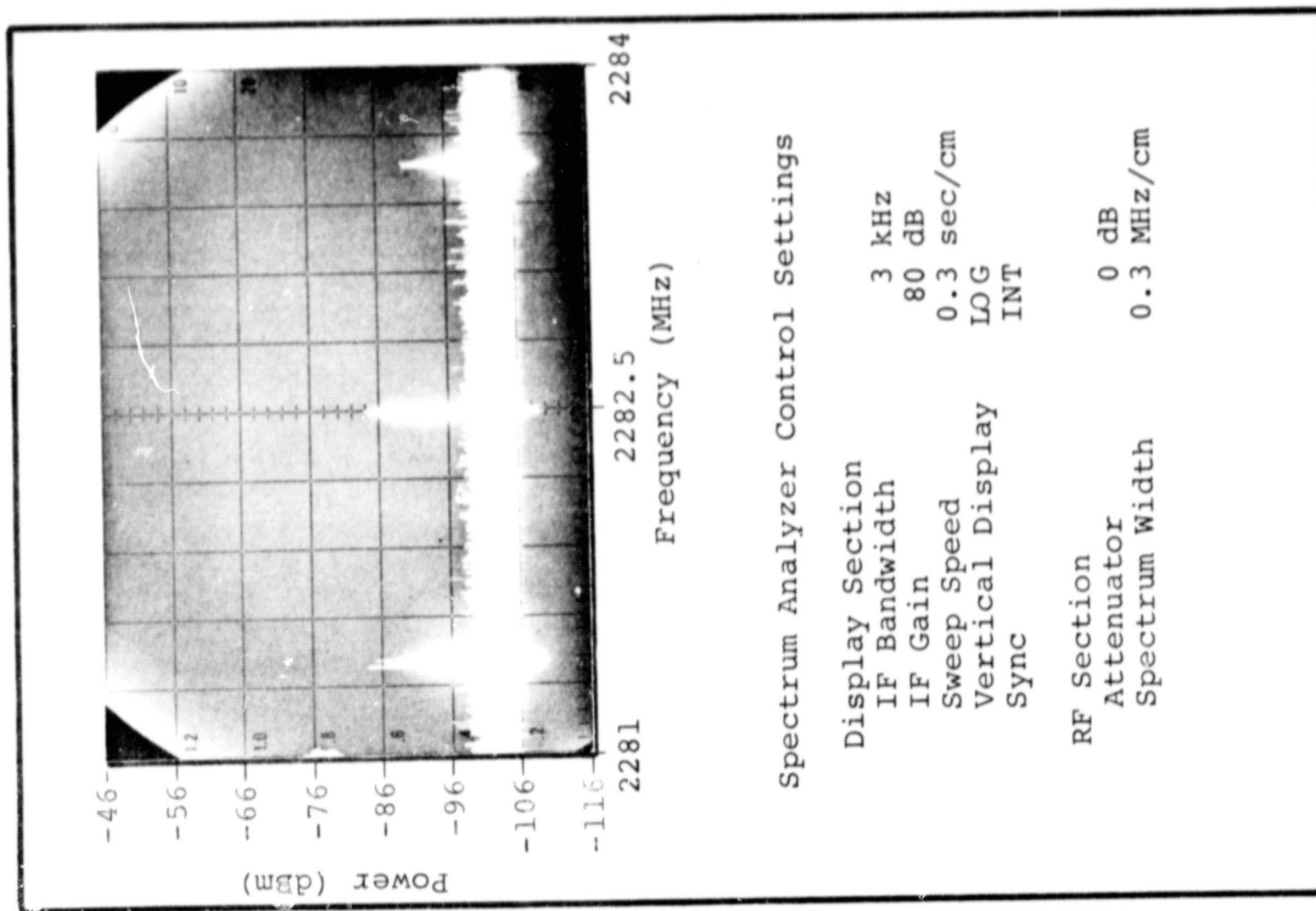


Figure 21. Typical CCS Vehicle High Gain Antenna Power (Closed Loop).

SECTION IV

INSTRUMENT UNIT AREA LEAKAGE MEASUREMENTS

A. GENERAL

Signal strength measurements were taken around the Instrument Unit (IU) of the AS-501 located in High Bay 3 of the VAB to determine; (1) the power density leakage from the CCS vehicle antenna hats; (2) the amount of RF leakage suppression obtained from the clam shell of the service structure; and (3) the amount of RF leakage suppression obtained by placing Eccosorb covers around the CCS vehicle antenna hats. Also, the vehicle antenna terminal power was measured to ascertain whether the RF leakage source was the vehicle antenna hat or the transmission line from the antenna hat to the parasitic antenna.

B. TEST PROCEDURE

1. Test Equipment. The test equipment used to obtain the signal strength measurements around the IU is listed in table 2.

Table 2. Instrument Unit Area Leakage Measurement Test Equipment.

| Test Equipment | Manufacturer | Model | Serial No. |
|----------------------------------|-----------------|---------|------------|
| Calibrated Field Intensity Meter | Polarad | CFI | 3-8 |
| Calibrated Signal Generator | Hewlett-Packard | 8616A | 411-00101 |
| Directional Coupler | Narda | 3043-30 | 07284 |
| S-Band Horn Antenna | Polarad | CA-S | 3-11 |
| Tuning Unit | Polarad | CFI-S | 3-9 |

2. Measurement Configuration. The measurements configuration is shown in figure 22. The CCS vehicle antenna system consists of a high gain directional antenna, a low gain directional antenna, and two omnidirectional antennas (fig. 4). Omnidirectional antenna number 2 was terminated in 50 ohms.

3. Calibration. After a 30 minute stabilization period, the frequency of the CFI meter was adjusted to 2282.5 MHz, the center frequency of the CCS. The CFI operating controls were set as follows:

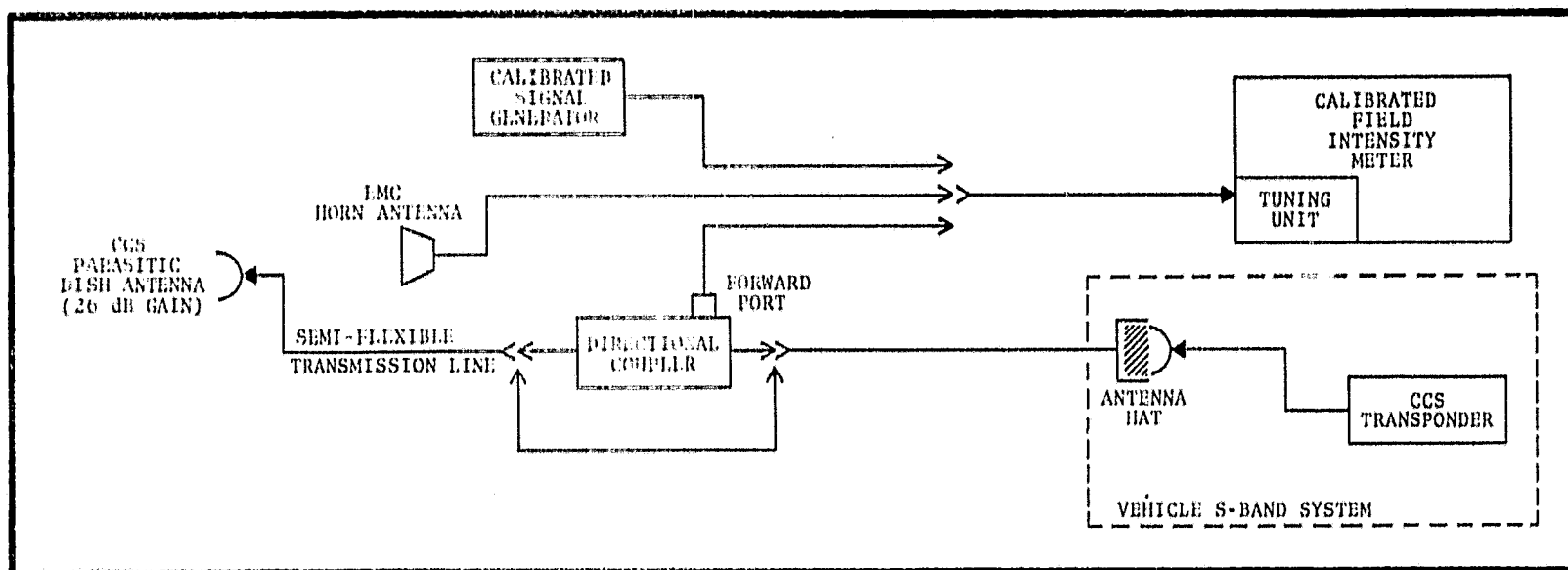


Figure 22. Instrument Unit Area Leakage Measurement Configuration.

Weighting function switch to OFF
 AURAL AID switch to OFF
 AM-FM switch to AM
 IMPULSE BANDWIDTH-MC switch to 1
 SCALE SELECT switch to μV
 CALIBRATE-USE switch to CALIBRATE
 RF ATTENUATION DECIBELS to 0
 All IF ATTENUATION out
 IMPULSE LEVEL DB ABOVE 1 $\mu\text{V}/\text{MHz}$ switch to 60

The IF GAIN control was adjusted for 1000 μV on the output meter. The calibration of the CFI meter was checked by placing the CALIBRATE-USE switch to USE, connecting the calibrated signal generator to the CFI meter and adjusting the calibrated signal generator output to 1000 μV . With the calibrated signal generator tuned to 2282.5 MHz, the CFI output meter indicated 1000 μV .

4. Procedure. With the directional coupler inserted in the transmission line (fig. 22) and the CFI meter connected to the forward port of the directional coupler, antenna hat terminal power was measured and recorded for each CCS vehicle antenna. The directional coupler was removed from the transmission line and the CCS vehicle antenna connected directly to the CCS parasitic antenna. The EMC horn was then connected to the CFI meter and RF power leakage was measured at the locations shown in figure 4 for each antenna and recorded. An Eccosorb cover was placed around the antenna hat of omnidirectional antenna 1 and RF power leakage was again measured.

5. Results. The CCS vehicle antenna terminal power is given in table 3; the RF power leakage results are given in table 4.

Table 3. CCS Vehicle Antenna Terminal Power Measurement Results.

| Antenna Type | Directional Coupler Loss (dB) | Line Loss (dB) | CFI Meter Reading (dB μ V) | Antenna Terminal Power (dB μ V) |
|------------------------------------|-------------------------------------|----------------------|--------------------------------------|---|
| High Gain Direc- tional Antenna | 20 | 9 | 103 | 132 |
| Low Gain Direc- tional Antenna | 20 | 9 | 103.5 | 132.5 |
| Omnidirectional Antenna 1 | 20 | 9 | 107.5 | 136.5 |

Table 4. RF Power Leakage Measurement Results.

| Antenna Type | Measurement Position (Fig. 4) | CFI Meter Reading (dB μ V) | Cable Loss (dB) | RF Power Leakage (dB μ V) |
|--|-------------------------------------|--------------------------------------|--------------------|-------------------------------------|
| High Gain Directional Antenna | 1 | 78 | 9 | 87 |
| | 2 | 64 | 9 | 73 |
| | 3 | 46 | 9 | 55 |
| | 5 | 44 | 9 | 53 |
| Low Gain Directional Antenna | 1 | 77 | 9 | 86 |
| | 2 | 60 | 9 | 69 |
| | 3 | 38 | 9 | 47 |
| | 4 | 53 | 9 | 62 |
| Omnidirec- tional Antenna 1 (without Eccosorb covers) | 7 | 88 | 9 | 97 |
| | 2 | 67 | 9 | 76 |
| | 3 | 43 | 9 | 52 |
| | 5 | 55 | 9 | 64 |
| | 6 | 76 | 9 | 85 |
| Omnidirec- tional Antenna 1 (with Eccosorb covers) | 7 | 71 | 9 | 80 |
| | 2 | 57 | 9 | 66 |
| | 3 | 27 | 9 | 36 |
| | 5 | 35 | 9 | 44 |
| | 6 | 48 | 9 | 57 |

As shown in table 4, the maximum RF power (97 dB μ V) was detected when the EMC horn antenna was located directly in front of omnidirectional antenna 1. The maximum power density leakage is calculated as follows

$$P_o = \frac{P_r}{A_{eff}} \quad (7)$$

where

P_o = the power density

P_r = the received power

A_{eff} = the effective area of the receiving antenna

Expressing equation (7) in dBW/m²

$$10 \log P_o = 10 \log P_r - 10 \log A_{eff} \quad (8)$$

$$P_o(\text{dBW/m}^2) = P_r(\text{dBW}) - A_{eff}(\text{dB meter}^2) \quad (9)$$

Since the maximum detected RF power was measured in dB μ V across 50 ohms, P_r can be expressed in dBW as follows:

$$P_r(\text{dBm}) = E_r(\text{dB}\mu\text{V}) - 107 \text{ dB} \quad (10)$$

$$P_r(\text{dBW}) = P_r(\text{dBm}) - 30 \text{ dB} \quad (11)$$

therefore

$$P_r(\text{dBW}) = E_r(\text{dB}\mu\text{V}) - 107 \text{ dB} - 30 \text{ dB} \quad (12)$$

substituting P_r in equation (12) for P_r in equation (9)

$$P_o(\text{dBW/m}^2) = E_r(\text{dB}\mu\text{V}) - 107 \text{ dB} - 30 \text{ dB} - A_{eff}(\text{dB meter}^2) \quad (13)$$

The effective area of the receiving antenna was -12.9 dB meter² and the maximum measured RF power was 97 dB μ V, the maximum power density leakage, using equation (13) becomes

$$\begin{aligned} P_o(\text{dBW/m}^2) &= 97 \text{ dB}\mu\text{V} - 107 \text{ dB} - 30 \text{ dB} + 12.9 \text{ dB meter}^2 \\ &= 28.1 \text{ dBW/meter}^2 \end{aligned} \quad (14)$$

The amount of the RF leakage suppression obtained from the clam shell of the service structure varied between 18 and 30 dB. This is shown in table 4 where measurements were taken at position 2, inside the clam shell and position 3, outside the clam shell.

The amount of RF leakage suppression obtained from placing an Eccosorb cover around the antenna hat of omnidirectional antenna number 1 varied from 10 to 28 dB.

SECTION V

CONCLUSIONS AND RECOMMENDATIONS

A. CONCLUSIONS

The following conclusions are based on the results derived from the foregoing tests:

1. An excessive amount of RF energy leaked from the antenna hats because of either mounting or design problems. In fact, the signal strength received at the USB station from the antenna hat RF leakage path was approximately the same level as the signal strength received from the parasitic re-radiating system, even after being attenuated by the walls of the clam shell and the VAB. This resulted in two equal signals, phase shifted because of path difference, at the USB receiver input. This condition caused multipath interference. When Eccosorb covers were placed around the antenna hats, the antenna hat RF leakage was attenuated by 18 dB, thus eliminating the multipath interference problem.

2. The CCS and CSM spectrum occupancy power density graph (fig. 18) indicates that with both systems operating, the power level of the CSM lower sideband is approximately 3 dB lower than the power level of the center frequency of the CCS causing interference.

B. RECOMMENDATIONS

1. To resolve the multipath interference problem, it is recommended that Eccosorb covers be placed around the vehicle antenna hats.

2. The interference caused by the lower sideband of the CSM can be resolved by either:

a. reducing the power of sidebands radiated by the CSM,
or

b. increasing the power radiated by the CCS by improving the parasitic antenna re-radiating system.